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RELIABILITY, VALIDITY AND APPLICATION OF AN IMPROVED SCALE FOR ASSESSMENT OF MOTION SICKNESS SEVERITY

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Recently the U. S. Coast Guard, with the cooperation of the U. S. Navy, performed a series of experiments to assess the influence of actual vessel motion upon crew performance, physiology and affective state (2). The present report focuses on the reliability and validity of combining subjective reports of symptomatology with objective reports of vomiting by experimenters in an expanded scale for motion sickness severity assessment.

APPARATUS AND PROCEDURE:

Eighteen young males (22.1 ± 5.05 yrs) were selected from the ship's company of a Coast Guard High Endurance Cutter for voluntary participation in this study. Subjects were in good health, and motion sickness history questionnaires indicated the subjects' susceptibility to be about average for their age group. The test environments were three vessels; a 378' Coast Guard High Endurance Cutter (WHEC), a 95' Coast Guard Patrol Boat (WPB) and a 89' Navy Semi-Submersible Platform (SSP). In all cases subjects remained below decks in compartments located approximately amidships, possessing similar physical characteristics and no external visual cues of vessel motion. All test compartments were fully instrumented to record temperature, humidity and both linear and angular accelerations of the vessel. The three vessels steamed in formation off the coast of Oahu, Hawaii in an octagonal pattern which was repeated twice in eight hours each day for three seperate but consecutive days. Each leg of the octagon was approximately 30 minutes in length and differed from adjacent legs by a 45 degree change with respect to the encounter direction of the primary swell. The condition of the seas remained fairly constant at sea state 2 throughout the three day period.

The signs and symptoms of motion sickness were scored after the method described in Kennedy, Tolhurst and Graybiel (1) but expanded to a seven vice five point scale. This was accomplished by weighting major and minor symptoms differentially. The presence or absence of signs and symptoms of motion sickness was reported by subjects on forms provided in the last five minutes of each steaming leg. These forms queried the subject regarding the 34 symptoms normally associated with motion sickness which included cerebral indicants (e.g. headache), gastrointestinal indicants (e.g. nausea, burping, emesis), psychological indicants (e.g. anxiety, depression, apathy) and other less characteristic items such as "discomfort". A response was required for each symptom using a rating of "none", "slight", "moderate" or "severe". The number of occurrences of a symptom in the previous twenty-five minutes was reported if appropriate. Responses from the subject's questionnaire were transcribed by one of the investigators (RSK) onto a worksheet and then after discussion of the scoring criteria were scored independently by two investigators (RSK and MEM). In addition to the independent scoring by the two investigators, a third rater (DAA), (unsophisticated regarding motion sickness symptomatology), and a computer subroutine (ADP), generated two additional sets of scores using the diagnostic criteria specified elsewhere (1). These four sets of scores were examined for interrater reliability via correlation analysis. The 7-point scaling method was then utilized to score raw symptomatology data collected aboard the 95' WPB during a pilot study (2) prior to the three vessel comparison.

RESULTS AND DISCUSSION:

Table I shows obtained interrater reliabilities. All are seen to be high ($\bar{r}$).95) and imply the calculated intrarater reliabilities as shown along the diagonal in parenthesis.

TABLE I: RATER RELIABILITIES

	RSK	MEM	DAA	ADP
RSK	(.98)	.95	.96	.96
MEM		(.97)	.95	.95
DAA			(.98)	.97
ADP	(N=864)			(.98)

Validity: Four measures of motion sickness aboard the three vessels were employed: 1) number of people vomiting 2) total number of vomiting episodes 3) average time of first vomiting response and 4) average symptomatology rating. The first three measures were to provide validity checks for the symptomatology rating. Each of the measures showed clear differences between the vessels and as the results turned out were essentially redundant. For the first measure, all but one subject (n=18) vomited aboard the WPB, only one subject vomited aboard the SSP and no reports of emesis occurred aboard the WHEC. The second measure showed that 82 - 84 episodes of emesis were observed aboard the WPB, one on the SSP and no episodes on the WHEC. The third measure showed that the average time to emesis was clearly shortest aboard the WPB. Finally, as can be seen in Table II, the average level of motion sickness symptomatology experienced aboard the WPB was substantially greater than on either of the two other vessels. This relationship held true for each day and over the entire three day period. Stated differently, experimenter's reports of vomiting provided the same information as the scored subjective reports of symptomatology and the average intercorrelation of these 4 variables is r=.70.

Application: With the validity and reliability of the Motion Sickness Symptomatology Severity (MSSS) scale established, a real world experimental comparison of MSSS scores and emesis data was sought. For this purpose raw symptomatology questionnaire data and recordings of

TABLE II: MEAN MOTION SICKNESS SYMPTOMATOLOGY SEVERITY SCORES FOR 3 VESSELS

	WPB	SSP	WHEC	$\bar{X}$
Day 1	4.95	2.18	2.42	3.18
Day 2	5.72	1.86	2.25	3.27
Day 3	4.81	1.67	1.21	2.56
$\bar{X}$	5.16	1.89	1.96	3.00

emesis episodes were obtained from a pilot study (2) conducted just prior to the three vessel comparison study.

The pilot study was conducted essentially in the same manner as the more comprehensive study with a few exceptions: a) only one vessel was utilized, the WPB, b) two seperate but consecutive steaming days followed a dockside control day, c) six male WPB crewmembers (vice WHEC crewmembers as before) served as test subjects for the three day study and d) their motion sickness susceptibility was average.

The motion sickness symptomatology plotted as a function of octagonal steaming leg is presented in Figure 1. It should be noted that motion sickness symptoms do not usually occur immediately in response to a stimulus and so the MSSS score for a particular leg has been offset slightly. However, it is helpful to consider that since some symptoms may have particularly long latencies - it is possible that motions in leg 1 could influence symptoms not only at the end of leg 1 but even in leg 2. With this in mind it is still clear that the encounter direction of the steaming vessel to the primary swell (1 - steaming directly into the swell, 2 - port bow seas, 3 - port beam seas, 4 - port quartering seas, 5 - following seas, 6 - starboard quartering seas, 7 - starboard beam seas, and 8 - starboard bow seas) has a direct bearing upon the incidence of emesis. A difference that was statistically significant, ($P < .01$) when comparisons were made between legs 2, 3 and 8 versus 5, 6 and 7. (Legs 1 and 4 represented transitions complicated by previous legs and were omitted.) The motion sickness symptomatology scale developed for this study has proven to be both a valid and reliable tool for the assessment of motion sickness onset and severity, and is not hampered by a lack of sophistication of scoring personnel when properly instructed. Furthermore, several valid indications of motion sickness may not be as advantageous as the MSSS from a statistical standpoint because the latter provides more continuous information during pre- and post emesis states. For example, vomiting episode differences (Fig. 2) showed the same functional relationship to steaming direction as did the symptomatology but these former differences were ($p=.10$) not statistically significant and the latter were ($p<.01$). The use of the MSSS method has provided significant real world evidence that the direction of swell encounter by a surface vessel, such as the WPB, plays an important role in the provocation of motion sickness. When the vessel was steaming into the seas, theoretically producing higher motion frequencies and greater accelerations than if the vessel were riding with the seas, the severity of motion sickness symptomatology was greatest. In addition to the influence of the seas upon the motions of the vessel, the design characteristics of the three surface vessels studied produced dramatically different levels of illness. The 89' Navy experimental vessel (SSP), which represents a radical change from traditional monohull ship design, produced only very minor levels of sickness which were equivalent to those levels produced by the much larger and heavier Coast Guard High Endurance Cutter (378' WHEC).

Hopefully, the use of this improved methodology for the assessment of motion sickness severity will aid scientists and engineers in providing answers to the questions about improving human habitability aboard present and future marine vehicles.

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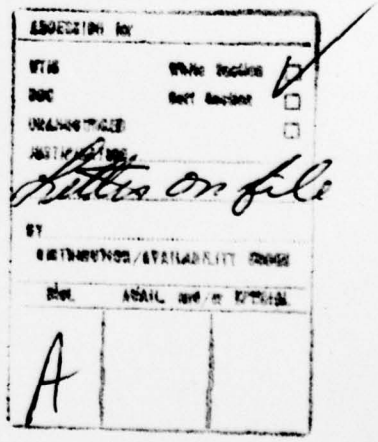

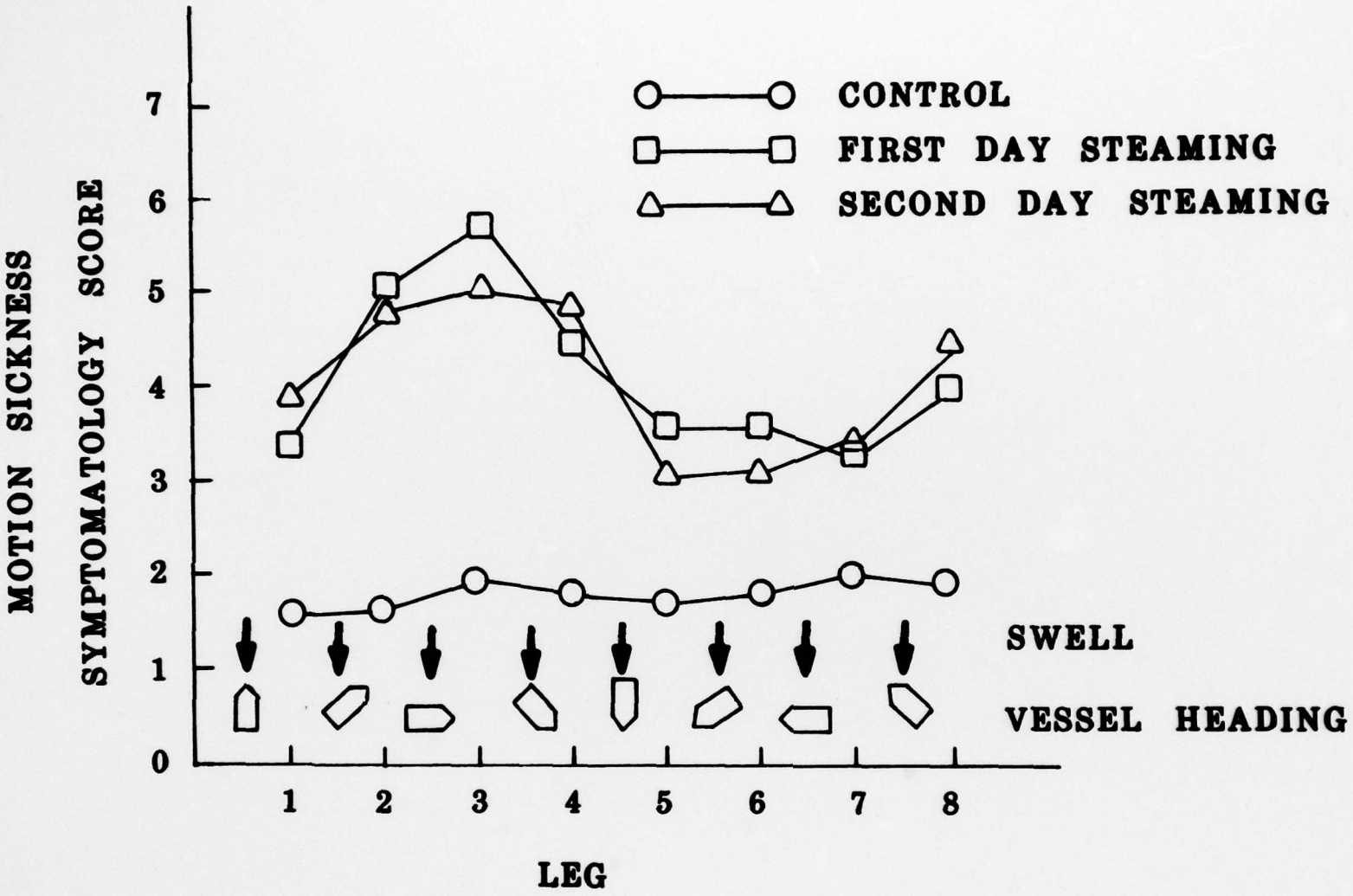

FIGURE I. MOTION SICKNESS SYMPTOMATOLOGY

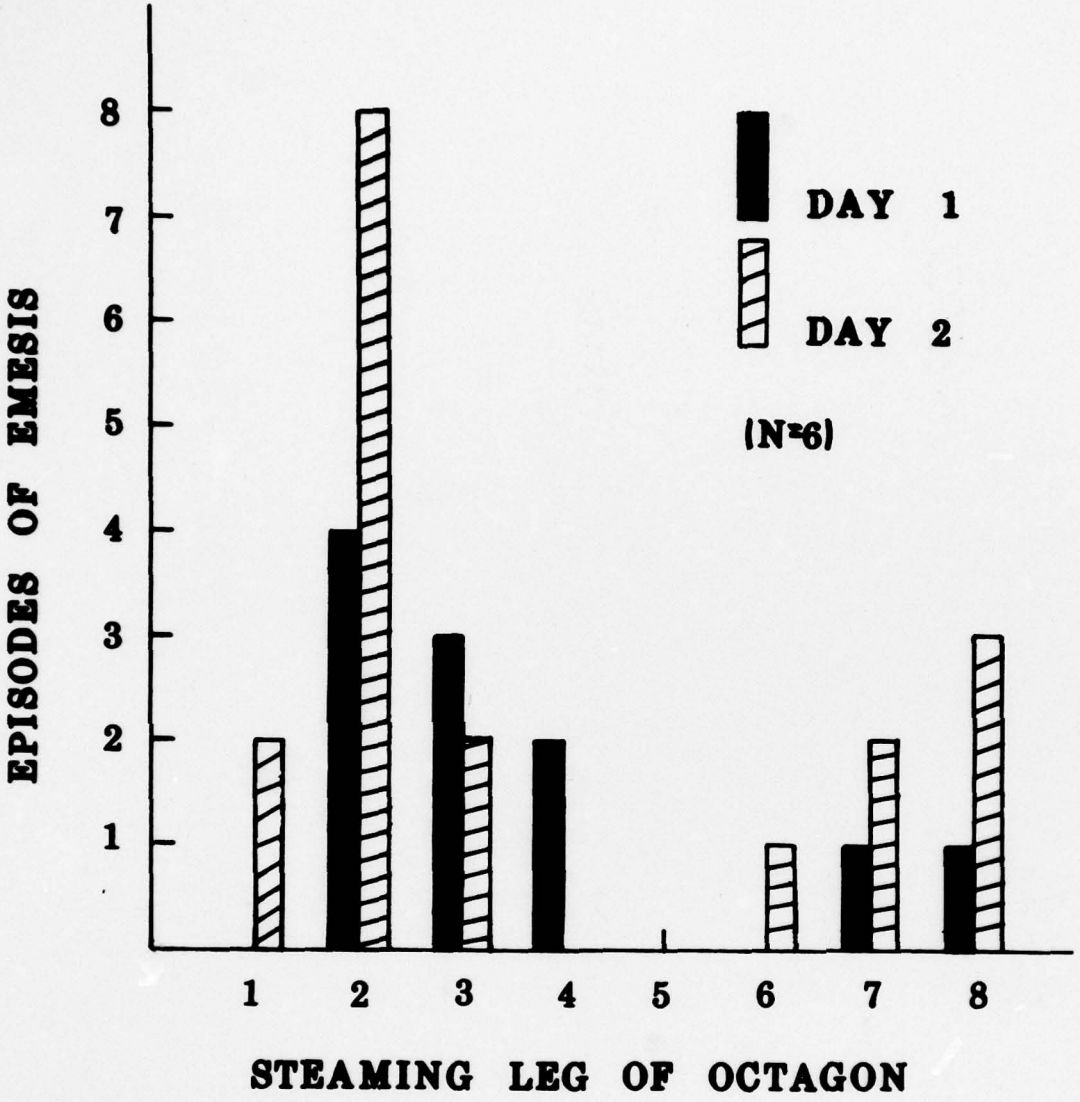

FIGURE 2. EPISODES OF EMESIS PER OCTAGONAL STEAMING LEG